

## SECTION 12

N72-29313

## SUMMARY OF 1971 WATER REMOTE SENSING INVESTIGATIONS

by

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INTRODUCTION

The Earth Resources Laboratory (ERL) has undertaken a Sea Remote Sensing Program designed to use multispectral instruments and techniques to characterize near shore and deep bodies of water. It is recognized that other investigations on remote sensing techniques and the evaluation of remote sensing instruments have preceded the ERL program and are ongoing. It is the intention of the ERL program to build on these other elements of the Earth Resources Program throughout the investigations described herein.

The fundamental ERL concept is to define and use the appropriate combination of available remote sensing instruments which measure radiant energy in different parts of the electromagnetic spectrum to determine the physical and biological parameters that characterize a given water system. Furthermore, it is intended to formulate interrelationships of these parameters to define techniques that are of general applicability to water system problems and to demonstrate their application to channel management (dredging), pollution definition and tracking, probable fish location, and marine resource assessment and management.

A major parameter of any water system is its circulation. Unfortunately, this is a difficult one to measure directly using remote sensing techniques. However, it is one which, when defined, forms the basis for the physical characterization of the body of water. The transport of suspended matter and bottom materials, the mixing of chemical constituents and the distribution of nutrients and pollutants are all elements of the water system which may be more easily studied once the circulation is known. Therefore, circulation has been chosen as a focal point around which the characterization of a water system may be built.

Because circulation is a difficult parameter to measure directly by remote sensing, an approach must be devised to infer this parameter from measurements of other water system parameters. Techniques are available or under development for measuring parameters such as surface

temperature, surface salinity, and chlorophyll. Photographic data allows an assessment of turbidity patterns, water color and some bottom features. Also, photographic dye marker techniques are being developed for obtaining circulation information that may be correlated with that inferred from the interrelationship of other parameters mentioned above. The intent, therefore, is to devise a method of interrelating these parameters such that circulation may be inferred.

In designing the initial laboratory programs, primary consideration was given to a program structure that would result in future technique application guidelines for the proper choice of (1) the type and combination of instruments to be used, (2) the quantity and location of surface measurements required, and (3) light, medium or high altitude aircraft or satellite sensor platforms depending on the physical nature of the water body such as its geographic size and shape or its depth. Three categories were selected around which to build the program. A large, deep body of water was to be selected for study using high altitude aircraft and satellite data. A coastal, medium sized body of water, relatively shallow and having typical estuarine characteristics, was to be selected for study using light and medium aircraft. And finally, a small body of water, a subsystem to the near shore water body, was to be selected for development of light aircraft techniques.

#### STATUS OF ACTIVITIES IN CY71

Two major investigations were initiated early in 1971 to develop remote sensing techniques for water systems and to evaluate presently available remote sensing instruments.

##### Deep Water Bodies

First an investigation was planned to develop remote sensing techniques to be applied to deep water bodies. The initial data on this project is being gathered by high altitude aircraft. However, it is intended that the techniques developed be extended to satellite altitudes and that optimum systems and procedures be defined for general applicability to the ocean current systems. It is not felt that the data from ERTS A will be directly applicable to this work. However, ERTS B and the Skylab EREP data will be used as an integral part of the project to develop ocean current remote sensing techniques. Dr. Robert D. Boudreau is the Principal Investigator on this investigation. The following is a brief discussion of the project.

The Eastern Loop Current in the Eastern Gulf of Mexico was chosen for this investigation because it represents a deep water current system with seasonal variations and because of its proximity to the Laboratory. The Eastern Loop Current enters the Gulf through the Yucatan Straits and exits through the Straits of Florida. The current is a seasonal phenomena in that its northern most extent proceeds northward during the spring and summer. The Loop becomes detached during the fall and the gyre drifts into the Northern Part of the Gulf. Figure 1 shows thermal contours in the Gulf indicating the boundaries of the Loop. This data was taken on the EGMEX program in April 1970.

This deep water current phenomena affords the opportunity of developing remote sensing techniques for defining surface thermal characteristics of a large body of water using high altitude, broad coverage instruments. Initial efforts have been directed at using the RB57F aircraft at 60,000 foot altitude and an instrument complement of a thermal scanner (RS-7), a thermal radiometer (Block and PRT-5), a filterwheel spectrometer and cameras to determine surface thermal patterns, and deep water chlorophyll concentration. It is planned to incorporate the Scanning Imaging Spectroradiometer (SIS) into the chlorophyll investigation when the instrument becomes available although it is recognized that recent information from Goddard indicated that the SIS capability may be limited for chlorophyll work.

The placement of aircraft flight lines has been and will be arranged in future flights to give total imagery coverage over a large area of the Gulf in an attempt to delineate the fine as well as the gross thermal features of the current system. The thermal radiometers are being used to measure radiation temperature along the flight lines while the thermal scanner imagery allows an assessment of thermal patterns. The filterwheel spectrometer is being used to develop techniques for the correction of data errors due to atmospheric effects. The photographic imagery provides data for the measurement of chlorophyll concentration and also provides knowledge of the percent and type of cloud cover as well as an indication of sea state.

The first mission in a series of four seasonal missions was flown on November 21, 1971. The area surveyed on that date is shown in Figure 2. The RB57F as well as the NP3A, a light aircraft and five surface vessels were involved. The NP3A, light aircraft and one surface vessel, as well as the RB57F, each carried a radiation thermometer (PRT-5) for the purpose of establishing radiation temperature and atmospheric effects on these measurements from several different altitudes. The five surface vessels took thermometer readings and water samples for chlorophyll analysis to establish surface calibration data for the remote instruments. A 200 mile surface temperature transect taken along Flight Line 3 by one of the surface vessels on an aborted

attempt to perform this mission on November 12, 1971, indicated a surface temperature distribution very similar to that shown in Figure 1. This data along with oral reports received from the Oregon II research vessel which was running transects in the Gulf for the EGMEX V program during the first three weeks in November gave confidence that the area to be surveyed covered at least a portion of the Eastern Loop Current. It was not possible at that time to extend the RB57F flight lines further into the Loop Current region because of aircraft navigation limitations. In addition to the surface water measurements, radiosonde data and surface weather observations were gathered during the mission to establish atmospheric parameters for use in an atmospheric data correction model being developed as a part of the project.

At the time of this writing approximately sixty percent of the NP3A and RB57F data from the November mission has been received from Houston and is being prepared for analysis. All surface data has been analyzed and reported in "Eastern Gulf of Mexico Remote Sensing Study, Experiment #1, Part 1, Surface Measurements," dated November 21, 1971.

### Coastal Water Bodies

An investigation was planned to characterize the physical parameters of a coastal body of water leading to the development of techniques for prediction of circulation from remotely sensed data. While the project described above is aimed at techniques to be used from satellites, it is appropriate to develop techniques for near shore bodies of water from medium altitude aircraft because of geographic size and instrument resolution required. This project is described in more detail in a companion paper, "Mississippi Sound Remote Sensing Study," by Dr. B. Houston Atwell, the Principal Investigator, and Dr. G.C. Thomann who is investigating the microwave aspect of the project. The following is a brief discussion of this phase of the program.

The Mississippi Sound was selected for the near shore study because of its nearness to the Earth Resources Laboratory, thus minimizing operational problems, and because of the interest of many local, state and federal agencies in its marine resources and protected water for shipping (Figure 3). Mobile Bay was included in this study because of the direct interaction of the Bay waters with the Sound waters. Also, the Sound interacts directly with the Eastern Gulf of Mexico.

The first two of four seasonal missions have been carried out in the Sound on July 22, 1971 and November 10, 1971. The missions have been scheduled to obtain seasonal and tidal variations in the data. Instrument complement, flight line placement, and altitudes flown have

been arranged to achieve definition of an optimum set of procedures for the determination of circulation and the associated parameters.

An integral part of this approach to studying coastal water systems through the use of remote sensing is the establishment of proper surface measurement techniques. During the development stage detailed surface parameter coverage is required so that the physical phenomena being measured may be understood and so that correct interpretation techniques may be established for the remotely sensed data. This detailed surface measurement coverage is being obtained in the Mississippi Sound Study through the cooperation of university, state and federal agencies in the Louisiana, Mississippi and Alabama coastal areas.

The participants in the study are shown in Figure 4. Their interest and cooperation in the study has made it possible to develop a very complete description of the water parameters from surface measurements during an overflight. Furthermore, these participants are considered among the eventual users of the remote techniques being developed and this cooperative effort has enhanced the pursuit of potential remote sensing applications in each of their respective areas of interest and responsibility.

At this time all of the NP3A data from the first mission and seventy percent of the NP3A data from the second mission have been received from Houston. Two reports on the surface measurements have been issued thus far entitled, "Mississippi Sound Remote Sensing Study, Part I, Surface Measurements from Experiment #1," dated July 22, 1971, and "Mississippi Sound Remote Sensing Study, Part I, Surface Measurements from Experiment #2," dated November 10, 1971. An interim report on the remotely sensed data from the July 22, 1971 mission is in preparation. It is planned to prepare and issue in the summer of 1972 a final report covering the four Mississippi Sound Missions.

#### SUPPORTING ACTIVITIES

A supporting activity receiving close attention and requiring considerable effort during ERL's first year was the establishment and implementation of efficient data preparation techniques for both the surface measurements and remotely sensed data. A major goal is to have all contour charts, plots, imagery mosaics and laboratory analyses of surface samples for the major water parameters completed in a timely fashion. Goals of one month for the preparation of a surface measurement report and three months for preparation of the remotely sensed data collected by Houston aircraft have been established. The one

month goal has been met on the last two missions carried out in mid November and it is expected the three month goal will also be met on those two missions.

The method used to achieve these goals was to identify a standard product to be prepared for each type of data. For example, upon receipt of the photographic imagery the first step is to prepare actual flight line maps noting the time of the imagery on the map and the orientation of the frame. Throughout the rest of the analysis all data are keyed to this map. All surface data and radiometer data are contoured on 1/250,000 charts for ease of comparison in establishing interrelationships between the parameters. These standard products are illustrated in the paper "Mississippi Sound Remote Sensing Study," by Dr. B. Houston Atwell and Dr. Gary C. Thomann.

Another area of supporting activity during the first year of the program was the establishment of standardized procedures for taking surface measurements such as temperature, salinity and chlorophyll, the establishment of coordination methods for taking surface measurements over large areas during aircraft overflights and the proper distribution of sampling points to allow correct interpretation of the remotely sensed data. Methods have been devised and successfully demonstrated that allow fifty surface crews from several different universities, state and government agencies to sample more than 100 different surface locations over a 1000 square mile body of water during a three to five hour aircraft mission. As the techniques are developed it is intended to reduce the number of sampling points to the minimum required for general usage of the procedure.

Similar coordination procedures were also required and developed for the several aircraft usually participating in these missions as well as for the retrieval of surface samples and the gathering of weather information. Requirements documents, flight plans, instruction packages and sampling kits for surface crews, and premission briefings have all become part of the standard operating procedure prior to a mission.

#### PLANNED ACTIVITIES FOR CY72

Plans for CY72 include the completion of the remaining flights on the Mississippi Sound and Eastern Gulf of Mexico investigations and the publication of reports on the results of these technique development activities. These reports will include a description of the instrument complement, appropriate sensor platforms and altitudes, and the procedures necessary to characterize bodies of water and an

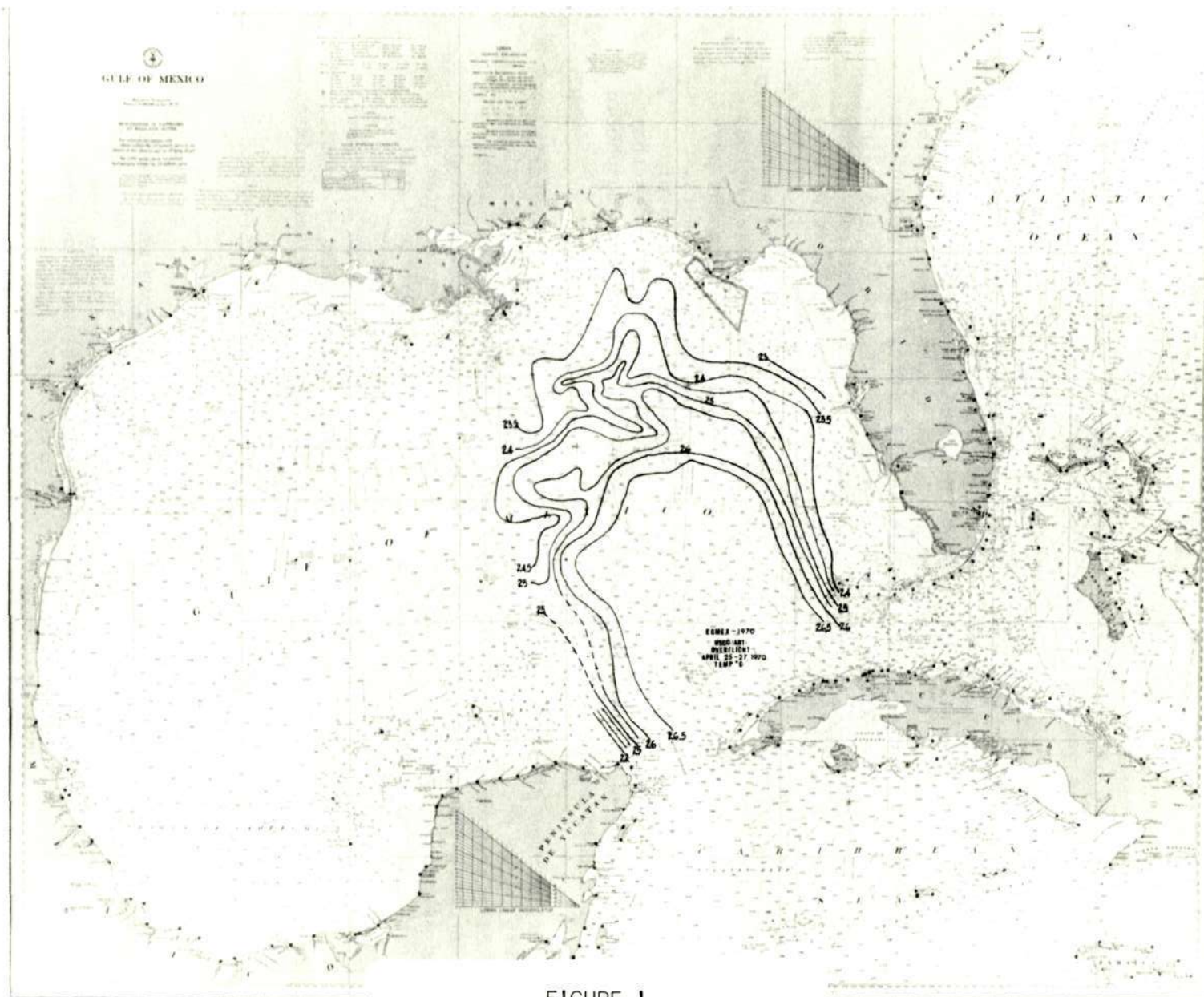
assessment of the products to be derived from the techniques. Figure 5 shows a schedule perspective for the Sea Remote Sensing Program.

In addition, several other investigations will be initiated in 1972. A more intense study on a relatively small body of water will be conducted to develop low altitude, light aircraft remote sensing techniques. Biloxi Bay on the coast of Mississippi has been chosen for this study because of its relationship as a subsystem in the Mississippi Sound water system and because it is a biologically productive area with significant historical data available from previous studies. This will be a cooperative effort with the Gulf Coast Research Laboratory playing a significant role in the gathering and analysis of surface measurements and in the correlation and interpretation of the data. It is planned to make monthly remote and surface measurements of the physical and biological parameters in the Bay over a one year period. Again the objective is to develop the technique for defining the physical and appropriate biological parameters using remote sensors. The use of a light aircraft at low altitudes over small bodies of water can be a useful, economical tool for developing techniques that may later be extended to higher altitudes as procedures and atmospheric correction techniques are developed.

It is also planned to conduct an investigation in the Barataria Bay region on the Louisiana coast for the purpose of further development of microwave/salinity techniques and to demonstrate the water system characterization techniques developed during the Mississippi Sound investigation. This effort will be planned and implemented in cooperation with the Corps of Engineers (New Orleans District) and with several universities already doing research in the area. The Gulf Universities Research Corporation has chosen the Bay as a primary test area thus making available a capability for collection of detailed surface measurement data for correlation with the remotely sensed data.

#### SUMMARY

The first year of the ERL Sea Remote Sensing Program was concentrated on project planning, data acquisition procedures and data preparation techniques to establish a firm procedural basis for the program. Most of these procedural elements were established and proven during the three missions conducted in CY1971. It is anticipated that the program in CY1972 will see the analysis completed on the Mississippi Sound series and the first series of Eastern Gulf experiments allowing increased emphasis to be given to more intensive technique development studies, the interrelationship of parameters for the measurement and prediction of water circulation, and the demonstration of the application of these techniques.





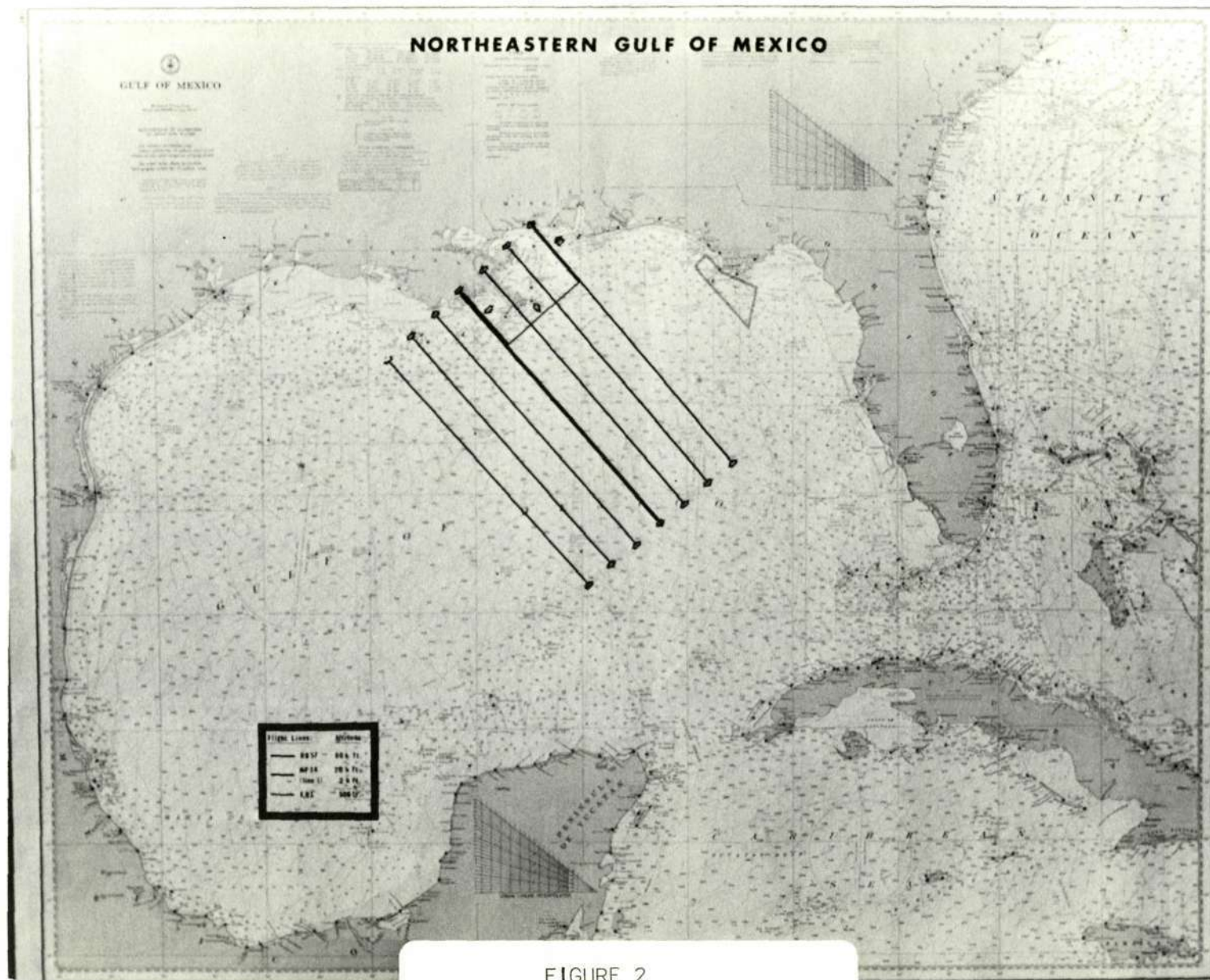


FIGURE 2

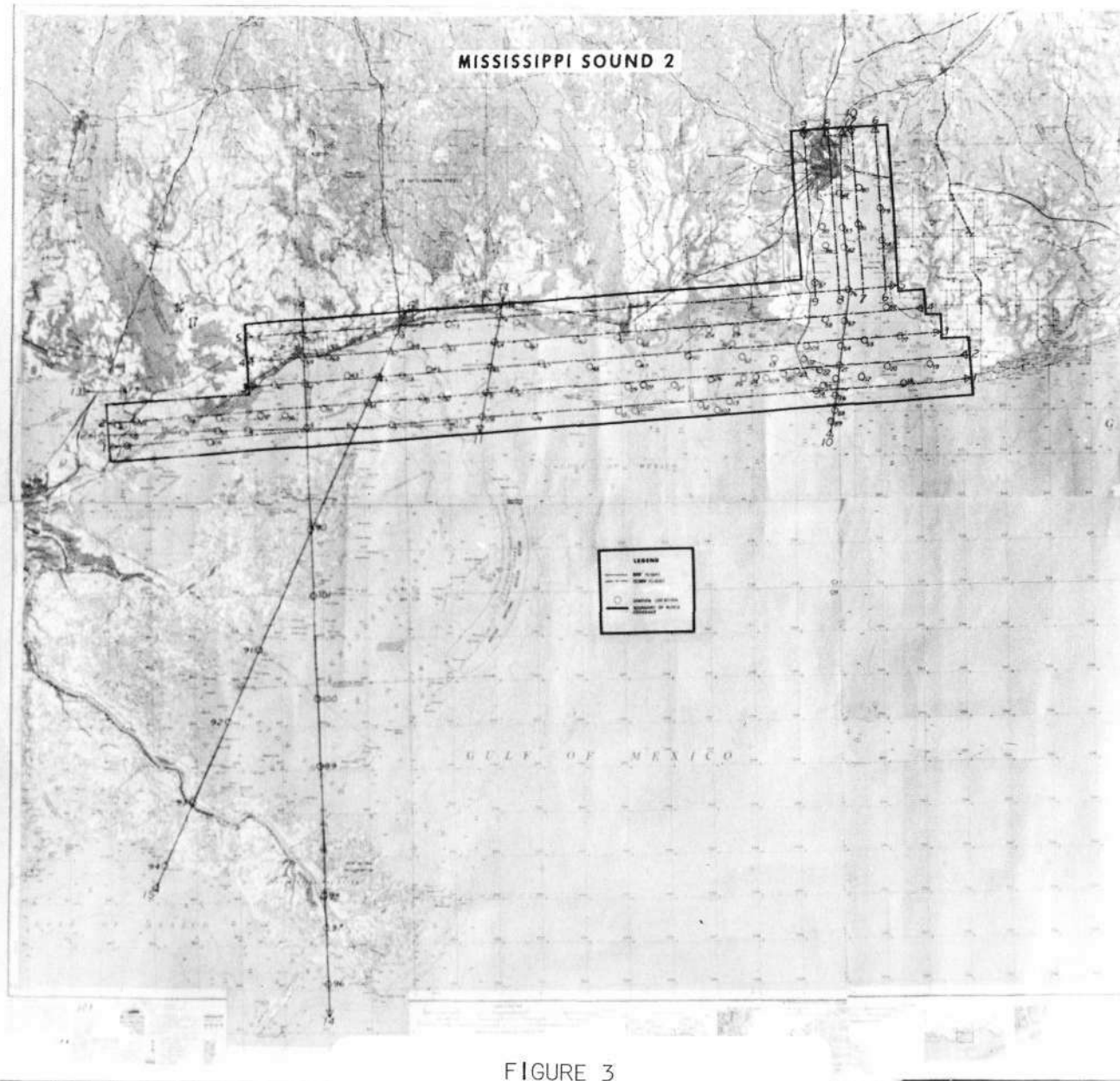


FIGURE 3

## MISSISSIPPI SOUND STUDY PARTICIPANTS

ALABAMA DEPARTMENT OF CONSERVATION  
GULF COAST RESEARCH LABORATORY  
LOUISIANA STATE UNIVERSITY  
LOUISIANA WILDLIFE AND FISHERIES  
MISSISSIPPI MARINE CONSERVATION COMMISSION  
MISSISSIPPI STATE UNIVERSITY  
NATIONAL MARINE FISHERIES SERVICE  
NOVA UNIVERSITY  
TULANE UNIVERSITY  
UNIVERSITY OF ALABAMA, MARINE SCIENCE INSTITUTE  
U.S. FOOD AND DRUG ADMINISTRATION  
U.S. CORPS OF ENGINEERS - MOBILE, ALABAMA  
U.S. CORPS OF ENGINEERS - NEW ORLEANS, LOUISIANA

FIGURE 4

# SEA REMOTE SENSING PROJECTS SCHEDULE PERSPECTIVE

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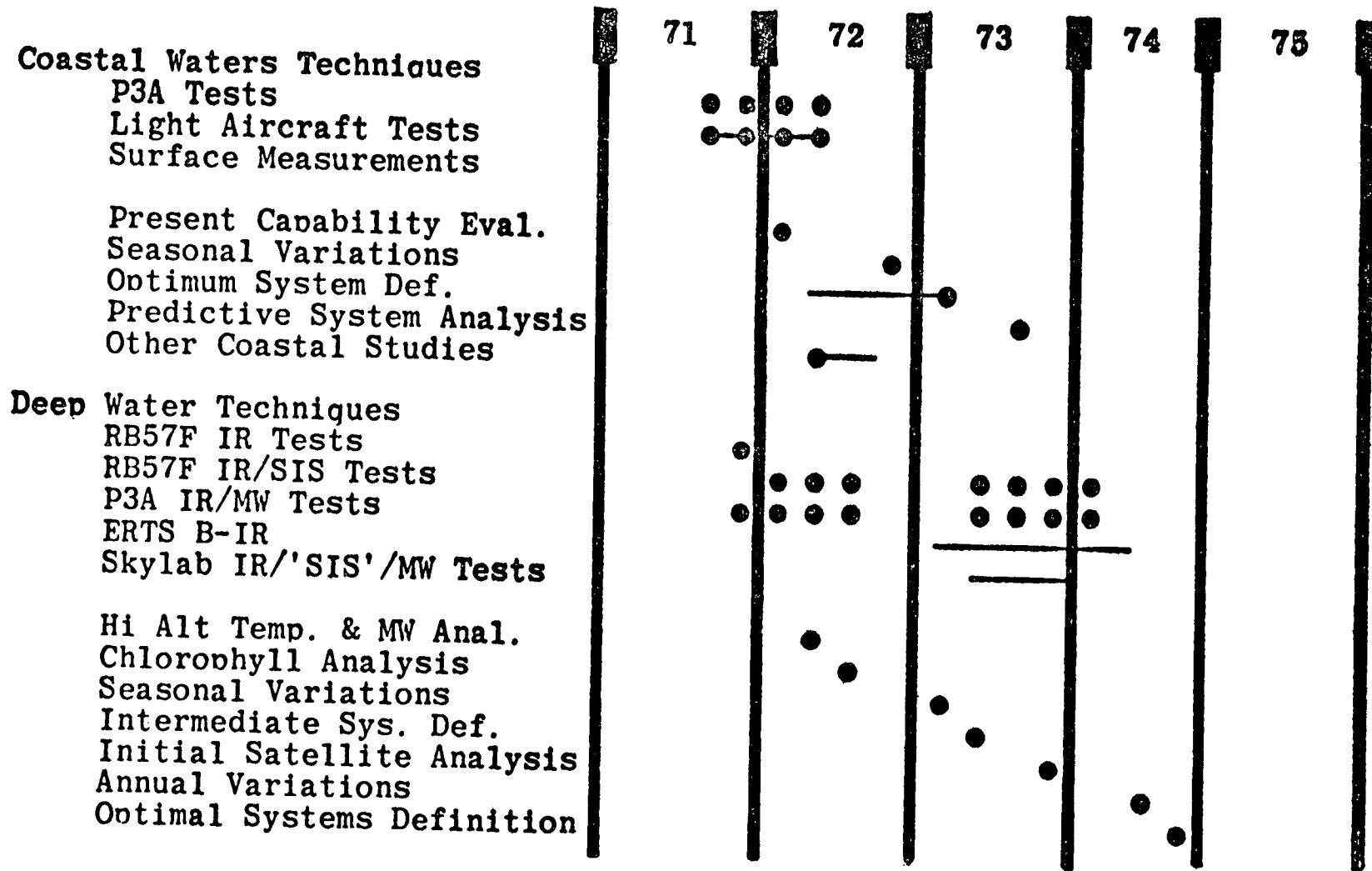


FIGURE 5